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Utilization of renewable energy sources for power generation in Iran

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Abstract

Utilization of non-renewable energy sources not only results in environmental deterioration but also confronts us with the dilemma of a rapid rate of depletion of such resources, while renewable energy sources can serve us indefinitely with minimal environmental impacts as compared with fossil and nuclear fuels.

This article deals with the extent of harnessing renewable energy sources for power generation in Iran, a Middle Eastern Asian nation.

Keywords: Renewable energy; Depletion; Resources

Contents

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1. Introduction

The Earths total energy sources may be divided into two major groups as follows:

A Non-renewable energy sources including fossil and nuclear materials as well as fuels of plant origin.
B Renewable energy sources which include solar, wind, geothermal heat, ocean waves, biogas etc.

The utilization of non-renewable energy sources in the developing countries with low levels of technological knowledge not only results in environmental pollution but also confronts us with the dilemma of a rapid rate of depletion of such invaluable resources while renewable energy sources can serve us indefinitely with minimal environmental impacts as compared with nuclear and fossil fuels. That is why a gradual replacement of non-renewable energy sources with renewable ones has been of major interest for most countries and poses as one of the most important issues of today. The development of new and sustainable energy sources has become one of the basic challenges facing researchers and scientists engaged in producing electricity and heat for billions of the earth's inhabitants. Iran, located in the Middle East not only enjoys vast and valuable deposits of fossil fuels and natural gas which contribute to her national economy and export earnings in a major way but also is a rich country in terms of renewable energy resources where scientists and researchers have made special efforts in finding and developing renewable energy sources as well as adopting related technical knowledge in the process.

In this article, an evaluation is made of the extent of power generation with renewable energy sources worldwide and then the related figures for Iran are presented which include contributions by water, wind, solar, geothermal heat and similar sources in producing electricity in the country.

2. Power generation with renewable energy resources worldwide

As can be seen from Table 1 about 2800 billion kW h of electricity is generated annually worldwide with renewable energy resources that include water, wind, solar, biogas and geothermal heat comprising about 20% of the earth's total electricity consumption (14,000 billion kW h) [1].

Hydroelectric power makes up the greatest share or 96% of the renewable sources. The next largest share goes to geothermal heat sources producing 1900 MW of power and 49 billion kW h of electricity.

Wind power generators with a total power of 13,500 MW and 23 billion kW h of electricity generation ranks third. The last sources on this list include solar energy with a power generation in the scale of 0.9 billion kW h and Photovoltaic generators producing 0.1 billion kW h of electricity.

Table 1
Annual rates of electricity production worldwide using renewable energy resources [1]

Rank	Energy source	Power	Energy (kW h × 10^{-9})
1	Hydraulic	669,000	2690
2	Geothermal	7900	49
3	Wind	13,500	23
4	Solar	325	0.9
5	Photovoltaic	700	0.7
Total		691.425	2763.6

2.1. *Trend in the development of renewable energy resources for electricity generation*

Electric power generated with renewable energy resources will continue to reach a level of 3200 billion kW h by 2005 based on the current rates of increase and to 3500 billion kW h by the year 2010 on the same basis.

If the increase in electricity generation is to amount to 2% every year some 16,000 billion kW h of electricity would be needed for the year 2005 and 17,500 billion kW h for 2010.

In other words the share of renewable energy would be 20% of the total for both 2005 and 2010.

Currently a figure of 12 billion Euro per year is considered for the construction of power generators using renewable energy resources. The figure should increase to 30 billion Euro by the year 2010 [2].

3. The role of renewable energy resources in electricity generation in Iran

The per capita electricity consumption in Iran has increased from 156 kW h 35 years ago to 2015 kW h in 2001 or 13 fold. About 95.5% of this power is generated by the Dept. of Energy. The shares of electric power produced at different locations by the Dept. of Energy in 2001 are recorded in Table 2.

During the recent years environmental pollution, population increases as well as per capita electricity consumption etc. have made the Dept. of Energy to utilize renewable energy resources to produce electricity as described below.

3.1. *Hydroelectric power plants*

Water power has been used to generate electricity for a long time in Iran where such stations have been in operation for over half a century. Fig. 1 shows the percent contribution by hydroelectric power station to the total power production by the Dept. of Energy.

As can be seen about 40 years ago some 36.4% of the total electricity produced with renewable energy came from hydroelectric power stations whereas, today that figure is only 8%.

With a growing concern about environmental issues in recent years as well as a general awareness about the limited supplies of fossil fuels as compared with clean renewable hydroelectric power supplies that provide additional advantages such as

Table 2
The share of various Kinds of power plants in the country's system of electricity generation

Rank	Type of power plant	%
1	Steam power plants	54
2	Natural gas plants	36
3	Hydroelectric plants	8
4	Diesel generators	2
Total		100

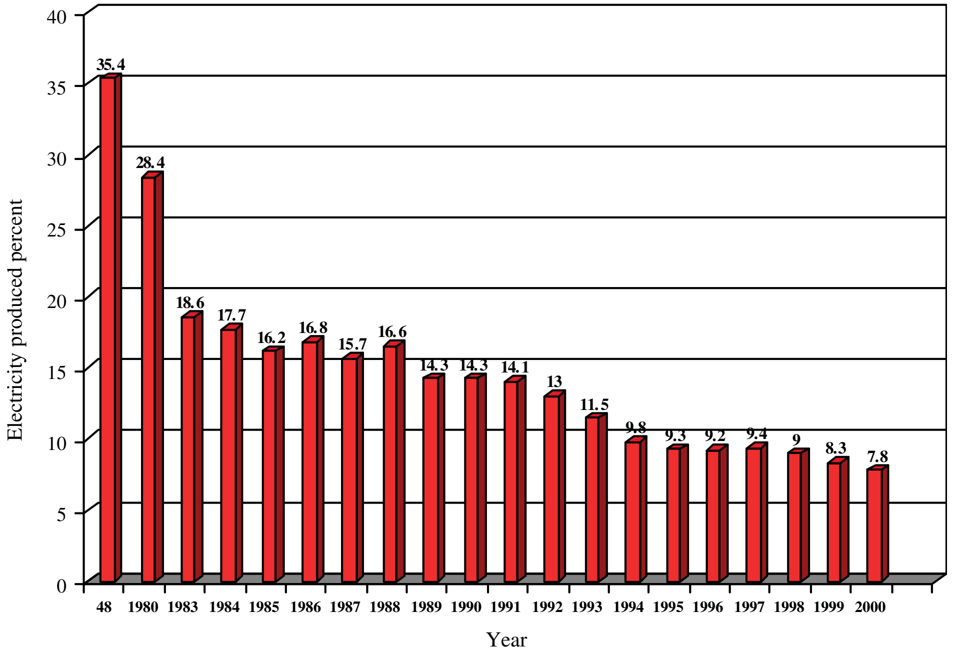


Fig. 1. The share of hydroelectric power stations in the Dept. of Energy's total production during the recent years.

flood control and means for regulating irrigation and drinking water supplies and the fact that this country enjoys a considerable potential for developing hydro-electric power, all have lead to substantial efforts in recent years to use hydroelectric plants for electricity. Table 3 Lists the country's potentials for hydroelectric power generation.

It can be seen that at the present time in addition to the Dept. of Energy's operating power stations with a total capacity of 1998.5 MW, new stations with a total capacity of 15,366 MW are either under construction or in the planning stage.

Furthermore, the Dept. of Jahade-Agriculture has embarked on a program of developing and constructing small hydroelectric power stations which according to the current plans should make about 4200 MW available to consumers.

Table 3
The potentials for hydroelectric power generation in Iran

Current status	Power capacity (MW)
Dept. of Energy's power station in operation	1998.5
Agr. Dept. Operating power station	7.7
Large power station under construction	7880.0
Large power station in planning stage	7486.0
Med size power station in planning stage	206.0
Small size Power station (1000–2000 kW)	1180.301
Mini size Power station (100–1000 kW)	234.825
Micro size Power station (up to 100 kW)	2.577

3.2. Wind power

Based on calculations, Iran enjoys only a moderate supply of wind power, with some regions having continuous air flows with sufficient energy to produce electricity (the average wind velocity in such regions is measured at about 5 m/s). Fig. 2 is a map showing wind velocities across Iran approximated for a height of 25 m above ground. The potential capacity of wind power is figured at about 6500 MW for the country, mostly in the eastern sections [3].

3.2.1. Developing wind potential for power generation in Iran

The development of wind powered generators has gotten a deserving attention during the last decade leading to the construction of the country's first such power station. Table 4 shows the level of power production and the number of wind turbines in operation.

3.2.2. Development of wind driven generators in Iran

Regarding the fact that some regions of the country have good potential for power generation by wind steps have been taken to construct two such stations since 2003 as follows:

A The 25 MW wind driven generator at Manjiel
B The 60 MW wind driven generator at Manjiel

3.3. Solar energy

Solar energy is the energy released from nuclear fusion within the sun. This energy is the source of other forms of energy on the surface of the earth (except for nuclear energy and the geothermal energy. The amount of solar radiation received by any given location on the earth varies with the climatic conditions and/other location characteristics.

Iran is potentially one of the best regions for the utilization of solar energy, and according to the data given in Fig. 3 the average solar radiation per square meter equals 4 kW h, where the average number of hours with sunlight is measured to exceed 2800.

The average number of sunlight hours are, of course, exceeded in Kavir regions such as the city of Yazd where it could reach an average of 3200 h, and where the intensity of solar

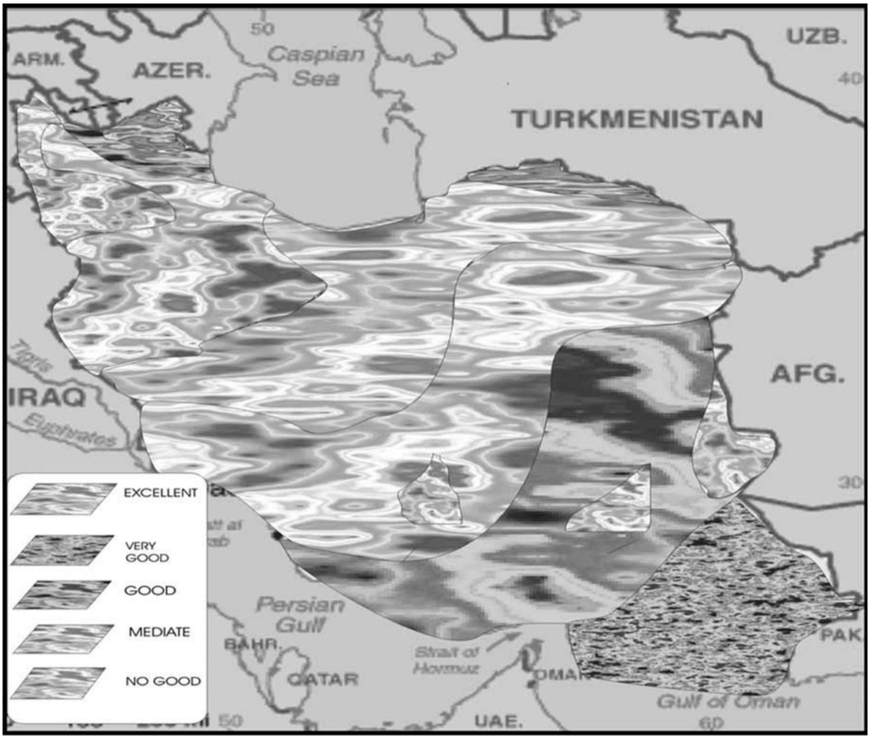


Fig. 2. An approximate map of wind currents at 25 m height is Iran.

Table 4
Level of electricity generation and the number of operating wind turbines in Iran

No.	Year	No. of operating wind turbines	Electric power (kW h)
1	1994	2	0.14
2	1995	2	4
3	1996	2	4
4	1997	11	6/3
5	1998	25	18.5
6	1999	27	36.2
7	2000	27	33.8
8	2001	27	33.6

radiation also exceeds the given values quoted before. Currently solar heated systems, water heater and solar baths are in use in various parts of Iran.

Table 5 shows some specifications for some operating solar projects and the managing institutions.

3.4. Geothermal energy

Regarding the favorable potentials of available internal energy of the country; studies have been conducted to develop such energy resources along with other renewable energy

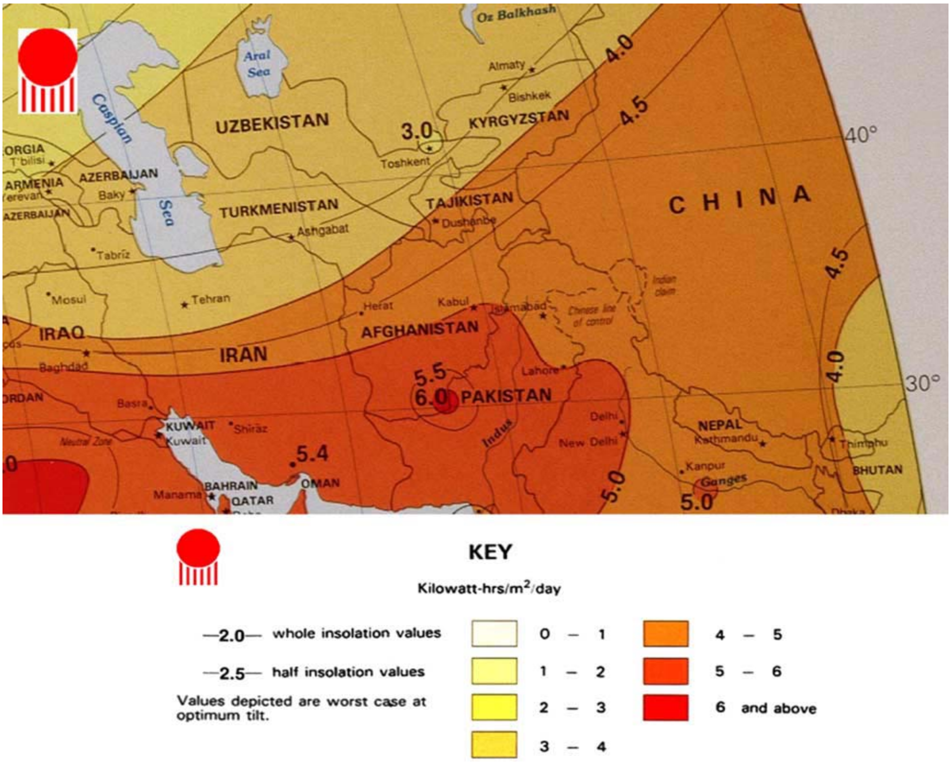


Fig. 3. The rate of solar radiation in different regions of Iran [4].

sources. The internalgeothermal energy has been estimated to provide about 1400 MW of power for the consumers in Iran. The Dept. of Energy has began work on projects for indirect utilization of the geothermal energy sources in Ardabil province since 1996. The useful capacity of geothermal energy in the region is estimated at 1200 MW where the capacity of the current project is 100 MW. It involves the use of steam as a power source which is then provided through the national network of power supply to the customers.

The project is expected to be completed by 2005.

3.5. Other forms of renewable resources

Initial work has already began in the areas of utilizing solar energy, fuel cell and biomass energy resources in Iran but have not yet resulted in power generation and are rather in primary stages as compared with the work on other renewable energy sources.

4. Conclusions

Regarding the completed work, it appears that there is a considerable potential for the utilization of renewable energy sources in Iran specially with respect to hydroelectric power, and solar radiation. However the level of development of such energy sources are rather primary, but efforts should increase because of the ever growing concern about the

Table 5
Some specifications on the operating solar energy projects and the managing organizations

Project name	Type of technology	State	Year began	Year of start	Project capacity (kW)
Dept. of Energy solar light	Photovoltaic	Tehran	1996	1997	1.485
Solar collector		Tehran	1997	1998	0.8
Photovoltaic pump	Photovoltaic	Tehran	1996	2000	3
3.5 kW photovoltaic system	Photovoltaic	Khorasan	1997	2000	3.5
Shiraz solar generators		Fars	1996	2003	250
Taleghan solar generator parts factory		Ghazwin	1997	2004	1000
45 kW photovoltaic	Photovoltaic	Tehran	1999	2002	45
Solar water heater					
Yazd;Khorasan;-Systan	2000	2004	3		
Iran's Atomic Energy Agency					
Design and construction of photovoltaic station	Photovoltaic	Yazd	1993	1994	5
Design and construction of photovoltaic station	Photovoltaic	Semnan	1994	1995	27
Design and construction of photovoltaic station	Photovoltaic	Yazd	1999	2000	10
Design and construction of photovoltaic station	Photovoltaic	Semnan	1999	2000	92
Jihade-Agriculture Dept. photovoltaic pumping system	Photovoltaic	Tehran	2001	2002	5.76

Table 6
A total list of power production with renewable energy sources up to 2001

No.	The type of renewable energy	MW	Million kW h
1	Hydroelectric power-Dept. of Energy	1998.5	3587.13
2	Hydroelectric power-Dept. of Agr.	7.7	13.82
3	Wind powered generator	10.8	34
4	Solar energy	4.442	11.1
5	Geothermal	–	–
6	Other sources	–	–
Total		2021.442	3645.05

environmental pollution caused by burning fossil fuels as well as the fact that we will run out of such non-renewable fuels anyway.

The total amount of power produced with renewable energy sources until 2001 are listed in Table 6.

Based on the total electricity production in the country in 2001, only 8.9% of the power was generated with the renewable energy resources mostly as hydroelectric power (8%), that is the share of other energy sources such as solar, wind, etc add up to about 0.9% indicating that we have only taken initial steps in the process of utilizing renewable energy resources in comparison with other countries and that much more efforts would be necessary.

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